

DARWIN FILE
(Selected Geo. Walker slides)

SUMMARY OF DARWIN SLIDES -- BUILDING RESEARCH STATION COLLECTION

GENERAL VIEWS OF DAMAGE

- 1.34 1. View of central city area. Larger commercial buildings generally performed well with the main damage being to roofing, where metal decking was used, and to windows.
- 1.21 2. Moderately damaged residential area -- Larrakeyah. The percentage of intact houses is much higher than the average over Darwin. Location in a depression normal to the wind was probably a factor in their survival.
- 1.26 3. View typical of the most seriously damaged areas. In this instance the clear fetch in the middle background may have been a contributing factor to damage in the foreground.
- 3.34 4. Heavily damaged houses in Northern suburbs.
- 1.7 5. View in worst damaged suburb of Nakara. Less than 2 years old, nearly 100% of all houses in this area were damaged beyond repair.

BEHAVIOUR OF LARGER BUILDINGS

The majority of larger buildings, especially those containing a significant engineering input, performed well.

- 1.32 6. Travelodge Hotel demonstrates typical behaviour of large multi-storey buildings. Structural frame is undamaged. Damage to windows was mainly confined to those adjacent to corners. Damage also occurred to metal deck roofing and to infill brick wall cladding.
- 1.31 7. Darwin High School. Schools performed well, even in areas where housing performed very badly, and they became major centres of relief. Darwin HS was located on a cliff top overlooking the sea. Engineering input in the design of schools was high.
8. Group of industrial steel framed metal clad industrial buildings showing typical performance. This most commonly involved blowing in of doors and loss of a small amount of roof cladding at ends of building and along ridges, examples of all of which can be seen in this slide.

- 6.28 9. Steel framed industrial building which completely collapsed. This was one of 4 identical buildings which collapsed. The main cause of the collapse appeared to be inadequate attention to instability of the light gauge cold formed sections which formed the roof members of the main frames.
- 7.6 10. Community College lecture building showing collapse of 1st Floor level structure on the windward side. It consisted of reinforced concrete columns continuous with the ground floor columns and 1st floor beams, supporting a light metal roof through a light truss spanning from the top of the outer columns to the inner columns.
- 7.13 11. Same building as in slide 10 taken inside adjacent wing where the failure had commenced but collapse had not occurred showing buckling of the bottom chord of the truss at mid span which it is believed triggered off the collapse shown in slide 10. It appeared that the bottom chord had not been designed for wind compression buckling it being assumed that if this occurred it would be elastic and recover following the gust.
- 8.20 12. Saw tooth structure which failed in the windward bay as shown.
- 9.17 13. Same building as in slide 12 showing trusses buckled downwards. It is believed that this was the primary failure and that the infill masonry wall collapsed subsequent to it.
- 5.6 14. School Assembly hall showing loss of roof and wall claddings. Such failures were nowhere near as common as larger buildings as they were on houses.
- 6.27 15. Steel framed industrial structure showing end bay failure as a result of buckling of purlins in the end two bays. The purlins were required to transmit the end loads (the main wind was incident on the end wall) through two bays in order to be picked up by the cross bracing in the walls and to support the roof loads. It is believed a combination of these loads led to the failure.
- 23 16. Steel framed industrial building in which complete failure of the end bay occurred, most probably due to the effect described in slide 15. In this instance the cross bracing was in the end bay. The failure of the end bay led to the rest of the structure relying on the cladding for bracing and the additional loads this imposed on the cladding connections may have been a factor in the extensive loss of cladding from this building.

11. 19
17. Failure of cavity brick wall which had been used to hold down the roof using tie rods anchored to approximately 5 ft of brick wall. Uplift had apparently exceeded dead weight, the wall failed at the anchorage level, blew inwards and collapsed.
- 5.7
18. Similar failure to that in slide 17. Roof, supported elsewhere by steel columns anchored to the foundations, was in this corner supported by a brick wall into which it was anchored approximately 5 feet.
- 5.10
19. Failure of infill cavity brick wall in school building. A considerable number of such failures occurred in both brick and concrete masonry infill panels.
- 5.9
20. Consequence of failure described in slide 19. ~~Collapsed~~ brick filled the stairwell. Had children been using the stairs to move from the top to the bottom floor at the time of the collapse the results could have been very tragic.
- 10.12
21. Old masonry building which was also subject to the 1897 cyclone during which it apparently suffered similar damage. Most buildings of this vintage and form of construction suffered virtually complete destruction in Tracy to the disappointment of the historically conscious citizens.
- 9.32
22. Many of the larger government buildings in the city area were provided with sunshading of which one type is shown in this slide. It appeared that in general this sunscreening had also provided a considerable degree of protection to the windows during the cyclone.

APARTMENT BUILDINGS AND FLATS

- 3.11
23. Typical apartment building after 'Tracy'. Light metal clad roofs were blown away and considerable destruction of the upper floors occurred. The remaining floors were generally relatively undamaged other than for window damage.
- 4
24. This apartment building which was conspicuous for its lack of roof damage, had a concrete roof.

HOUSING

Housing suffered enormous damage, and its failure was the basic reason for the magnitude of the disaster and the consequent evacuation of a large proportion of the population.

It can be classified in 3 groups:

timber framed high set; masonry low set; and others

Timber framed High Set Houses

- 4.21
25. Typical appearance of a timber framed high set house. It is really a single storey house on piers, with asbestos clad walls, and corrugated iron clad roof.

This older style design had steel piers and a hipped roof. Later designs used concrete piers and gable roofs and were mainly rectangular in plan.

- 5.10
26. General view of a collection of high set homes which survived, largely due to being in a depression normal to the main directions of the wind during the cyclone. At the time this photograph was taken some of the roofs had been reclad with corrugated iron.

- 1.18
27. Failure of roof cladding only. Over 90% of all houses in Darwin suffered from a significant loss of the roof cladding, which was mainly corrugated iron. It was more commonly the only significant damage in older houses such as this one than in newer houses, where loss of roof cladding appeared to have such a weakening effect as to lead to further failures.

- 2.11
28. More typical of newer houses was complete loss of both roof and wall cladding. The failure of the roof cladding appeared to be strongly influenced by fatigue effects and the failure of the wall cladding appeared to be strongly influenced by racking, there being a lack of bracing in the frame itself. Note the windows which have blown out, frame and all, as a complete unit due to an almost complete lack of fixing of the window frames to the timber frame of the house.

- 2.7
29. Racked frame of newer house which was a consequence of loss of cladding and lack of bracing in the walls.

- 2.4 30. Complete collapse of timber frame of new high set house.
- 2.3 31. Result of collapsed high set houses was a tangled mass of debris such as shown in this slide being inspected by Dr Bob Leicester and Greg Reardon of CSIRO.
- 2.22 32. Edge roof purlin showing screwed fixings for roof cladding still in place. There was strong evidence that corrugated iron fixing failures were strongly influenced by fatigue effects which led to its failure at loads much less than would have been predicted by static load tests.
- 11.14 33. Recently built high set house showing many signs of failure. Roof cladding has gone, walls have started to blow in due to loss of roof at roof level. (The corrugated iron was relied upon for horizontal bracing of the walls at roof level), and concrete piers have failed at foundation level due to lack of bracing.
- 2.2 34. Failure of infill block walls between piers which were expected to provide bracing of piers. Lack of reinforcement and continuity with piers was probable cause of these failures which were common in high set construction. Number of failures of piers was however small probably because of (i) bracing effects of stairs, and (ii) failure of top half of house reducing wind loads on the piers.
- 3.17 35. Some older type high set homes. In general older homes performed better due primarily to better bracing. Hip roofs were much more common in this group and contributed significantly to the bracing.
- 10.9 36. The piers collapsed on this older home. Similar failures on newer homes tended to lead to complete collapse of the house.
- 7.32 37. Houses clad externally with ribbed metal cladding performed better than average, apparently due to better ability to withstand debris impact, and better fastening of cladding to timber frame.
- 1.16 38. This high set home had been strengthened by the provision of external battens on top of the roof cladding which were tied down at ends. Government approval had been received just prior to the cyclone for all Government owned older houses to be strengthened in this manner in the belief that older houses were at greater risk from typical cyclones!

blown in. The fact that the roof withstood the additional forces this would have imposed indicated that the strengthening had probably played a significant part in the survival of this house.

MASONRY LOW SET HOMES

- 2.32
40. The most common single storey homes consisted of cavity brick walls on a concrete floor, supporting a timber framed corrugated iron clad roof. The older houses of this type were typified by this slide. Hip roofs were common supported on a concrete ring beam on the top of the brick walls which was tied into the brick walls at the corners. As a group these survived better than any other major class of house, the most common damage being partial loss roof cladding as shown in this slide.
- 3.31
41. A relatively common sight in areas of mixed housing was of the older low set masonry homes remaining intact surrounded by the wreckage of the neighbouring high set houses.
- 5.29
42. Older low set masonry home with complete loss of roof cladding. Gable roofed houses of this type did not perform as well as similar houses with hipped roofs owing to the roof providing less support to brick walls which because of the large window openings were dependent on support at roof level. There were a number of cases of end wall failures of this type of building.
- 8.27
43. Recently built masonry house with a tiled roof. Tiles performed no better than corrugated iron.
- 5.22
44. Older masonry house showing evidence of lifting of ring beam due to roof uplifts. Note crack in wall approx 5'0" down where ring beam had been anchored into the cavity brick wall.
- 6.36
45. Recent low set brick homes of standard construction performed very poorly. Flat roofs and gable roofs were used almost exclusively with a bond beam along the top of the two supporting walls only and not tied down to the walls. Roofs tended to lift off as shown in this slide followed by collapse of the unsupported brick walls which were themselves weakened from earlier designs by the use of a much larger cavity.

8.5 46. Another view of recently built collapsed masonry home.

6.2 47. Another view of a similar failure.

OTHER HOUSES

Because of the rapid growth of Darwin in recent years there had been some encouragement to industrialised systems built housing. By and large this performed better than the traditional housing probably due to the greater engineering input required in their design before they would be accepted by the authorities.

6.6 48. Modular concrete construction. The major failure of these houses was in the roof, unsecured concrete slabs being dislodged by the wind.

8.2 49. Timber panel wall construction. A proprietary system, this house suffered considerable damage. Investigations showed that although there were designs for typical cyclone prone areas, the local licensees of the system were unaware of them and were using designs developed for the southern part of Australia.

5.11 50. All metal prefabricated units generally performed very well. These were temporary classrooms at a school. Similar units were in use as accommodation at the hospital and a school and performed equally well.

3.15 51. Among the 'oddities' of the cyclone this old settlers cottage survived remarkably well despite being on the sea front. Iron clad walls and roof, protection from the tree and its small size, no doubt all contributed to its survival.

10.4 52. 'Futuristic' house did not perform so well. This fibre glass flying saucer shaped building came apart at circumference where minimal connections were placed. Apparently designers believed that its shape made it insensitive to wind action!